A3A09: Committee on Freeway Operations
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Freeway Operations in 2000 and Beyond

By Members and Friends of the TRB Committee on Freeway Operations

In the broadest context, freeway operations combat congestion and its damaging effects, which include driver delay, inconvenience, and frustration; reduced safety; and poor air quality. A comprehensive freeway corridor traffic management (FCTM) program requires a combination of approaches, techniques, systems, and operating policies aimed at establishing and maintaining a balance between highway capacity and vehicular demand. The basic principle underlying any FCTM program must be this: If demand is not allowed to exceed capacity, congestion will not occur—and operational safety and efficiency will be maintained.

To truly comprehend freeway operations and management systems and fully appreciate their potential to deal with congestion problems, first we must understand both the nature of congestion and the events that occur in the traffic stream as congestion forms. Freeway operation depends on the balance between capacity and demand. As vehicle demand approaches highway capacity, traffic flow begins to deteriorate. Flow is interrupted by spots of turbulence and shock waves, which disrupt efficiency. Then, traffic flow begins to break down rapidly, followed by further deterioration of operational efficiency. The result of this spiraling inefficiency can be observed during every weekday commute in almost every metropolitan area: Drivers push their way onto already crowded freeways to join thousands of others already caught in seemingly endless traffic jams. Unfortunately, by joining the already impeded traffic flow, drivers become part of the problem, creating even greater inefficiencies: more stop-and-go traffic conditions, longer delays, and greater potential for accidents.

The key to successful freeway operation is to prevent the traffic flow from breaking down and thus avoid the spiraling effects of inefficient operation. This goal can be achieved by applying an array of operational measures that can maintain the proper balance between capacity and demand. This balance equates to free-flow conditions with optimized levels of throughput and safety.

There is a paradox in all of this. The general public requires congested flow conditions as motivation to change travel practices—for example, to divert to alternative routes, to other times, or to high-occupancy vehicles. In fact, experience has shown that in the absence of congestion, the public is not willing to make such changes. Thus, the freeway operator finds that, to the degree that the FCTM program is successful in eliminating congestion, the public's incentive to make changes to achieve that success erodes. Such is the nature of the freeway operations program.

FCTM is a complicated task. It entails

- Understanding both the nature and magnitude of a particular congestion problem;
- Combining various operational strategies, policies, and systems into a comprehensive program;
- Proactively operating those systems to establish (or reestablish) and maintain the balance between highway capacity and vehicular demand to maintain free-flow conditions;
- Using technology, detection and verification systems, communication links, traffic operations centers, motorist information systems, and information sharing among systems;
- Implementing a high degree of interagency coordination and cooperation to provide emergency services and to restore accident scenes to normal operation in the shortest possible time;
- Deploying and implementing highly sensitive and sometimes controversial management strategies, such as ramp meters and high-occupancy lanes; and
- Managing extremely popular services such as tow trucks and patrols to rapidly remove disabled vehicles from freeways.

FCTM is all of this and more. Its components are aimed at providing some level of relief from congestion and improving safety to the traveling public.

WHERE WE HAVE BEEN

In the late 1960s and early 1970s, highway agencies began to take steps toward active operation of the freeways that had been constructed through the golden years of the Interstate Program. Emphases in highway transportation began to shift from building new facilities and enlarging existing ones to extracting the most from existing facilities. It was the dawn of the era of freeway operations and traffic management.

Authorities began to realize that understanding how the public used highways and how operating agencies managed that use was crucial to maintaining operational efficiency. Allowing unrestrained growth in the use of the freeway network produced congestion, which effectively reduced freeway capacity, lowered traveling speeds, and raised blood pressures. Tools that could manage and reduce the congestion plaguing our highways were sorely needed. Researchers used studies of highway usage to come up with the concepts and approaches that have since evolved into freeway traffic management programs. They realized that implementing these programs could cost-effectively influence the public's use of the highway system.

Agencies recognized that congestion was really one of two types: recurrent or nonrecurrent. The kind of congestion depends on whether the capacity or the demand factor is out of balance. Recurrent congestion occurs when demand increases beyond the available capacity. It usually is associated with the morning and afternoon work commutes, when demand reaches such a level that the freeway is overwhelmed and traffic flow deteriorates to unstable stop-and-go conditions. Technically, the relationship between volume and speed reaches the critical point, then collapses. Speed and throughput drop until a decrease in demand allows the relationship between speed and capacity to stabilize, and then speed increases again.

Nonrecurrent congestion results from a decrease in capacity while the demand remains the same. This kind of congestion usually results when one or more lanes are blocked. A stopped vehicle, for example, can take a lane out of service, but the same number of

vehicles expects to travel through. Speed and throughput drop until the lane is reopened, and then they return to full capacity. Whereas recurrent and nonrecurrent congestion have different causes, their solutions have many elements in common.

FCTM began with the following goals:

- To monitor congestion,
- To clear capacity-reducing incidents as quickly as possible, and
- To warn drivers of upcoming conditions.

Projects were developed and deployed to test the theories. Algorithms were created and refined as new information provided more insight into the problem and ways to detect it. The target was to alleviate the congestion that clogged freeways. For recurrent congestion, tools used included surveillance and control systems that featured detection systems, ramp meters, changeable message signs, and closed-circuit televisions cameras. Dealing with nonrecurrent congestion required the same infrastructure but more personnel involvement: interdisciplinary incident management teams, service patrols, and tow trucks. Motorist advisory systems worked under both conditions to inform motorists of incidents ahead. Documented improvements in congestion levels and highway safety helped to garner support in the early years.

Over the past three decades, the practice of freeway operations has matured. Strategies have evolved, techniques have been developed, and new technologies have emerged. Traffic operation centers have reported successes and failures as lessons learned. The intelligent transportation community has quickly incorporated those lessons, and the resultant systems have progressed with each new generation of the freeway traffic management system.

The development of the freeway traffic management system has been facilitated by factors that have reinforced the need for intelligent transportation systems (ITSs). As ITS projects have been deployed and successfully operated, agencies and decision makers have observed the benefits: Decreased congestion and increased safety cannot be ignored. Agencies have continued to invest in traffic management programs, in addition to conventional capacity expansion projects, to curb increasing congestion.

WHERE WE ARE TODAY

During the past few years, FCTM programs have become a somewhat standard package of systems that involve incident detection, confirmation, response, and information dissemination. Incident detection is done by monitoring traffic flow, usually by tracking volumes, speeds, and occupancy. Confirmation is made by cameras, agency vehicles, or police. Emergency response to a confirmed incident normally results from direct communication by either telephone or radio. Information dissemination makes use of variable message signs and media contacts to widely distribute incident information as traffic updates. Specific blends of technology depend on local needs and budget.

Current developments in freeway management systems focus on deploying infrastructure, integrating systems, and expanding the functionality of systems. Many miles of freeway now contain loop detectors and are monitored by cameras that produce traffic statistics as well as collect congestion and incident information, which is disseminated to the public in various ways. But with all the information being collected, current deployment lacks the development of policies, management strategies, and operating

procedures for the actions that should be taken. Both elements—the information and the policies—are needed to realize the maximum potential of FCTM systems.

Two public reactions to traffic management have given elected officials and operating agency management reason to resist deploying traffic- or lane-management strategies such as ramp metering and high-occupancy vehicle lanes. In many locations, the public has expressed strong dissatisfaction with traffic management measures that they perceive as ways to restrict or control their travel. However, when drivers encounter congestion, they rarely divert to alternative routes, delay their travel, or cancel their trips. Such reactions have hindered the continued expansion—and have affected the credibility—of freeway management systems.

WHERE WE NEED TO GO TOMORROW

Implementing an FCTM system is an expensive endeavor. We should optimize the benefits through careful expansion, thoughtful study, and aid to the public in understanding how they can best use the systems. In envisioning our industry in the new millennium, we have looked backward to establish how we arrived here. The history of traffic management tells volumes and helps us set a course for the future.

To fully realize the potential of ITSs, FCTM systems must expand their infrastructure in several directions, building on what has been accomplished already to extend the reach of data collection and information dissemination. The infrastructure must be expanded to keep ahead of the moving line that represents the boundaries of congestion. Similarly, traffic advisory coverage must be extended to reach motorists before they enter (and add to) freeway congestion. The implementation of traffic management infrastructure on both freeways and parallel surface streets will provide commuters with knowledge about the entire network, optimizing their route selection and helping them realize the full potential of FCTM systems.

Developing detailed response plans helps to optimize system benefits and to ensure that lessons learned are applied consistently to new situations. Including emergency vehicle and media notification, signing implementation, and record keeping as part of a response plan saves time when initiating a response. As a result, the response to any incident will be as complex or as simple as necessary.

Little effort has been expended to coordinate the interactions of police, fire, and ambulance crews beyond their previous experience together. Several agencies are working to develop response plan teams who work with the police and other emergency services to ensure that reestablishing the traffic flow—although secondary in importance to safety—remains a priority.

Throughout the history of FCTM systems, research has focused on detecting incidents or congestion as close in time to the initial occurrence as possible. Then, traffic management systems respond to alleviate the constriction to the highway system. Anticipating or predicting the locations of congestion or incidents before they happen and working to prevent them will allow traffic management to make the leap from being reactive to being proactive.

The next logical step for ramp metering is to use this subsystem to maintain free-flow conditions at all times and to limit freeway access to the vehicle volume that will not degrade traffic flow to stop-and-go conditions. Travel on the freeway infrastructure is a valuable commodity, and the change in philosophy that leads to this understanding will take some time. Roadway pricing and toll roadways are the first steps in this transition.

What benefits can or should commuters expect from the application of FCTM infrastructure? The future challenge will be for operators to avoid overextending the public's expectations of the systems. Traffic management does produce benefits, but we have to be careful how we sell them. The benefits exist, but we as a profession must work to encourage the understanding that FCTM is simply one piece of a large puzzle for relieving congestion. FCTM alone is not the answer.

THE CHALLENGES OF TOMORROW

States and metropolitan areas are exploring both traditional and innovative ways to address increased travel demand, growing traffic congestion, declining mobility, the continued need to improve safety, and other significant issues that face the surface transportation system. These challenges provide an opportunity for agencies to work together and learn from each other.

The reality of urban mobility is that there is only one public and only one road system. The public deals with high levels of congestion in all transportation modes on a road network supported by a single taxpayer. FCTM is one "tool" trying to ease the congestion. Ingraining these simple truths into the way that we conduct our business will be the biggest challenge in the near future.

To the average commuter, the transition from local artery to freeway is seamless. Route planning includes the entire network of area roads, not only the freeway. Unfortunately, the public does not always receive information about the level of congestion on these routes in a similarly seamless manner. Traffic management has developed under the philosophy that there is a strong delineation between travelers and the road system they use, an us-versus-them mentality. The capacity of the arterial road network has been closely guarded; cars backed up at ramp-metering stations are closely watched to prevent any overflow that could block an artery. Traffic management on arterial road networks rarely works with traffic management systems on freeways. Overcoming the built-in prejudices that prevent information sharing with commuters is a challenge that we must meet soon to realize the entire benefit of ITSs.

The public must be given realistic expectations. For years, the public has been told that technology will solve all of its problems. We have to be vigilant to ensure that the view of the public toward FCTM systems is not jaundiced by overoptimistic expectations and longer-than-expected delivery times. The benefits of the systems are real, and the benefits of investing in FCTM already are being realized. However, industry insiders must remember that whereas the benefits for society as a whole are large, the benefits perceived by individual drivers on a daily basis may not be so impressive. We have the larger picture, and we must communicate realistic individual benefits to individual users.

The safety benefits of traffic management always have been overshadowed by congestion management, even though the two issues are related. Motorists appear to be increasingly concerned about safety and security. The safety benefits of roadway systems such as ramp metering will require better documentation and publicity. FCTM programs will need to incorporate new safety and security systems such as mayday systems, intelligent cruise control, and improved incident response or emergency medical systems (e.g., San Antonio's Life Link).

How we sell traffic management to elected officials, decision makers, and management is another challenge we will face in the future. Again, we must be careful in expounding the benefits of FCTM. As a stand-alone program, FCTM will not solve congestion; however, working with the other pieces of the puzzle, it will help to mitigate congestion.

FCTM must work with traffic management on the arterial road network, the long list of other ITS components, and urban planning to make an impact. Our twofold challenge is to contain our enthusiasm for FCTM and to sell it honestly.

Not only the external agencies remain dubious about the benefits of FCTM. Many jurisdictions continue to need reassurance that these traffic management tools are worthwhile investments—not only to build, but also to operate and maintain. In our own departments, the challenge continues to convince our superiors of the validity of our claims about overall benefits and the need to establish coverage across the entire network to maximize these benefits. Highway designers continue to resist including this specialized field within their projects, seeing the technology as superfluous to the basic need for concrete and asphalt. Ensuring that the infrastructure is protected during highway maintenance and replaced when damaged continues to be a struggle.

Funding for ITS initiatives always has been a challenge and is tied in closely with how well we sell the concept of FCTM. Because of tighter controls on money and a never-ending list of ways to spend it, we will continue to be challenged in the search for new sources of funding to continue expanding the existing infrastructure. Such new concepts as partnerships between the private and public sectors, outsourced design/build/operate contracts for transportation infrastructure projects, and user-pay scenarios will bring about new opportunities for funding. Expanding advertising, sponsorship, and "adopt-a-highway" plans to include traffic management will present options for funding operations. Partnerships to sell or share data and video signals will continue to provide new opportunities.

Funding for the operations and maintenance of expanding FCTM systems must be budgeted to realize their expected benefits. If funding is not budgeted, the investments will deteriorate and eventually become useless.

FCTM programs are "technology packages" used to operate and manage our freeway and arterial road systems. These packages are not ends in themselves. Operating agencies must place knowledgeable and trained staff in charge of the FCTM systems and proactively use and fine-tune them to better detect incidents and more effectively advise travelers of current conditions.